XVI. *On magnetic influence in the solar rays.* *By* SAMUEL HUNTER CHRISTIE, *Esq. M. A. F. R. S. of Trinity College, Cambridge; Fellow of the Cambridge Philosophical Society: of the Royal Military Academy. Communicated November* 15, 1825.

Read January 19, 1826.

THE object of the present communication is to show, by a series of experiments, that the solar rays possess sensible magnetic properties, which are observable in the vibrations of a magnetised needle exposed to those rays, independently of the effects produced by the heat which they impart. I propose likewise to point out the changes which take place in the intensity of a magnetised needle from changes of temperature, as deducible from the times of its vibration. I have before stated in my paper *on the effects of temperature on the intensity of magnetic forces*, that, in deducing the terrestrial magnetic intensity by means of the vibrations of a needle, a correction ought to be introduced where the observations have been made at different temperatures. I had not at the time made any experiments by which I could ascertain how far changes in the temperature of a needle would be sensible in the time of its vibration; and the first observations which I made with this view being with a light needle, did not give very decided results: they however led me first to notice the very singular fact, that a magnetic needle comes to rest more quickly when vibrated exposed to the rays of the sun, than when vibrated in the shade.

In order to ascertain the effect which changes of temperature have on the times of vibration of a needle, it is necessary to know the temperature of the needle itself during the observations, and I saw no better means of ascertaining this, even approximately, than to vibrate it in the shade and then exposed to the rays of the sun, and to consider the temperature of the needle to be that indicated by a thermometer near to it. On my first doing this, I found, that although I could easily mark the 50th vibration when the needle was shaded, I could not distinguish beyond the 40th when it was exposed. I at the same time found that the time of vibration was slightly diminished at the higher temperature, instead of being increased, as I had reason to expect. As however the needle was not vibrated in the same spot in the two cases, the diminution in the time of vibration and of the arc when it was exposed, might be independent of the change of temperature and of any influence in the solar rays. To avoid any uncertainty arising from difference of disturbing causes in two situations, I placed the compass out of doors, with a screen composed intirely of wood, supported at the height of four feet above it, and by removing which the rays of the sun struck directly on the needle. A thermometer having the bulb near to the compass-box indicated nearly the temperature of the needle. When the shutter was up, so that the needle vibrated in the shade, I could very distinctly note the 100th vibration; but when it was removed and the needle vibrated exposed to the sun's rays, I could not so distinctly mark the 75th. I made use of a needle six inches long, weighing 42.75 grains, and contained in a brass compass-box with a glass cover: the needle was suspended by a fine hair, and commenced vibrating 30° from zero.

Needle exposed to the sun; or being in shade.	Thermometer.	Time of performing 50 vibrations.	Extent of arc of vibration from zero at 50th vibration.
Shade . .	60.9	118.8 seconds.	Not observed.
Sun . .	91.5	118.0	Not observed.
Shade . .	75.0	118.8	5° 00′
Sun . .	75.3	118.0	2 30
Sun . .	90.4	118.4	2 45
Sun . .	91.4	118.0	2 30
Sun . .	89.4	118.4	2 30
Shade . .	81.6	118.7	4 45

From these observations it is evident, that although the needle vibrated rather more rapidly, yet it came more quickly to a state of rest when exposed to the rays of the sun, than when in the shade. The latter effect appears to have been produced independently of the heat of the rays; since when the thermometer had risen only to 75.3, the terminal arc had decreased from 5° to 2° 30′. These observations were made between noon and 1^h 30^m on the 4th of June 1824, and I had no opportunity of repeating them during that summer.

As the apparent increase of intensity at an increased temperature, indicated by a small diminution in the time of vibration, excited my surprise as much as the more rapid decrease of the arcs of vibration when the needle was exposed to the rays of the sun, I resolved to make use of a balance of torsion, in order to deduce the changes of intensity from the deviation caused by torsion, as well as from the times of vibration; and that there might be less ambiguity in the results, I employed a much more powerful needle, its weight being 197 grains, and length 6 inches as before. This needle was suspended by a wire (No. 22) 22.9 inches long, and free from torsion when the needle pointed to zero. The observations

contained in the following table were made between 1 and 2 o'clock after noon on the 30th of May, 1825; as before, the vibrations commenced 30° from zero.

Needle exposed to the sun; or being in shade.	Thermometer.	Index on the micrometer of torsion.	Deviation of the needle.	Time of performing 50 vibrations.	Extent of arc of vibration from zero at 50th vibration.
Shade.	60	0°	- - -	158.35 seconds.	5° 45′
	60	0	- - -	158.25	5 40
	61	360	19 00		
Sun, but not strong.	73	360	19 10		
	82	360	19 16		
	80	0	- - -	158.7	3 10
	85	0	- - -	158.7	3 15
	87	0	- - -	159.3	3 05

Here, as before, the terminal arc was in all cases diminished when the needle vibrated exposed to the solar rays, but the increase of temperature caused a diminution of intensity, whether the intensity be estimated by the time of vibration or by the deviation caused by torsion. Estimating it by the latter, we shall have, since the directive force varies directly as the torsion and inversely as the sine of the deviation,

Directive force at temperature $61° = \frac{341}{\sin. 19°} = 1047.186$;

Directive force at temperature $82° = \frac{340.73}{\sin. 19° 16'} = 1032.624$.

So that with an increase of temperature of 21° there appears to have been a decrease of intensity of 14.552. This would give the decrement of intensity .00067 for an increment of 1° in temperature between the temperatures 61° and 82°, the intensity at 61° being considered 1. From the experiments with powerful magnets, detailed in my former paper (Phil. Trans. 1825. p. 1.) it appears that, considering the intensity at 62° as 1, the decrement of intensity corresponding to

an increment of temperature of 1°, between 62.05 and 77.65, would be .000586, from which the foregoing result does not differ greatly.

If we estimate the change of intensity by the difference in the times of vibration, calling the intensity at the temperature 60°, 1; we shall have,

$$\text{Intensity at temperature } 84^\circ = \frac{(158.3)^2}{(158.9)^2} = .992462.$$

We have therefore here a decrease of intensity .007538, in consequence of an increase of 24° in temperature; or a decrement .000314 corresponding to an increment 1° in temperature, between the temperatures 60° and 84°. This is considerably less than was deduced from the deviation due to torsion, which arises in some measure from the acceleration from torsion being very nearly constant at different temperatures, and therefore tending to diminish the difference in the times of vibration.

The following observations were made between $11^h\ 30^m$ and $12^h\ 40^m$ of the 10th of June, 1825, under very favourable circumstances, the sun shining clear and strong the whole time. The heavy needle employed in the last observations was again made use of; it now rested on the pivot. The point where the vibrations commenced for each 40 vibrations was 90° from zero.

Needle exposed to the sun; or being in shade.	Thermometer.	Time of performing 40 vibrations.	Extent of arc of vibration from zero at 40th vibration.	Times of commencing and of concluding the observations.
Shade.	72.5	135.0 seconds.	15° 30′	11^h^ 30^m^
	75.0	135.0	14 30	
	75.0	135.0	13 30	
	76.0	134.8	12 00	11 52
Mean .	74.6	134.95	13 52	
Sun.	90.0	135.3	8 00	11 55
	105.0	135.7	9 00	
	109.0	136.2	8 30	
	112.0	136.2	8 20	12 12
Mean .	104.0	135.85	8 27	
Shade.	87.0	135.4	12 30	12 20
	84.0	135.5	14 00	
	82.0	135.3	13 00	
	81.0	135.1	12 00	12 40
Mean .	83.5	135.32	12 57	

Deducing the changes of intensity from the times of vibration, the observations at 74°.6 and 104° give .00045, and those at 83°.5 and 104° give .00038 as the decrement in intensity corresponding to an increment in temperature of 1°, one of the observations being in the shade, and the other in the sun in each case; but from the observations at 74°.6 and 83°.5, where both were made in the shade, we have .00061: and again, from the observations at 90° and 110°.5 (the mean of 109° and 112°, the times of vibration at these temperatures being the same,) where both were made in the sun, we obtain .00064 as the decrement, the intensity at the lower temperature being in each case considered as 1. The small disagreement in the first two results may arise from errors in determining the temperature of the needle at the time of vibration, which, from the rapid changes that took

place, could not be ascertained with precision; and the much greater difference between either of these and the other two may possibly be attributable to the same source, though I shall have occasion at the conclusion of this paper to point out another, and, I conceive, the true cause of this difference. Had my object been to give a correction for difference of temperature, to be applied generally to the intensities deduced from the times of vibration, a closer agreement in the results would have been desirable; but although such is not my object, I wish, from these experiments, to point out the necessity of such correction, when we would deduce the magnetic intensity from the times of vibration of a needle in different parts of the earth, where the temperatures during the observations are necessarily different.

The observations which I have detailed are, I think, quite conclusive as establishing the fact, that the rays of the sun had a tendency to check the vibrations of the needle, particularly those in the last table; since here, on the needle being exposed to the sun, the terminal arc was reduced from nearly 14° to 8½°, and again on excluding its rays that arc was increased to nearly 13°: the only question is whether this would take place under all circumstances; that is, whether the influence be exerted in all cases directly on a magnetised needle and independently of changes in its temperature and intensity, or whether it was an effect produced on the metal of the box by a change in its temperature. That the effect is independent of changes in the temperature and intensity of the needle will appear from comparing the first observation in the sun with the first of the second set in the shade; the temperatures and times of vibration are very

nearly the same in the two cases, and yet in the sun the terminal arc is only 8°, whereas it is 12° 30′ in the shade. That the diminution of the arc does not arise from an increase of temperature in the box appears from this, that although the thermometer indicated 90° at the first observation in the sun, and 87° at the first in the shade, it is probable that the temperature of the brass compass-box was higher in the latter case than in the former, since in both this would change its temperature more slowly than the mercury in the bulb of the thermometer.

To ascertain beyond doubt whether these conclusions were correct, I placed the compass in a room where it was not exposed to the rays of the sun, and when the needle had acquired the temperature of the room, I vibrated it, and noted the time of 40 vibrations and the arc at the 40th; I then heated the compass-box over a fire until its heat was barely supportable to the hand, replaced and vibrated the needle. Instead of finding that the increased temperature of the box had diminished the terminal arc, I found that, at the end of the first 40 vibrations, it was considerably greater than when the box had been at a lower temperature, and that, as the box had cooled, the terminal arcs in the successive 40 vibrations decreased, the vibrations always commencing from 90°; and this effect was invariably produced in repeated trials. A thermometer was placed at a small distance from the compass, that any changes in the temperature of the air might be indicated: this remained nearly at the same point throughout the observations.

		Thermometer.	Time of performing 40 vibrations.	Extent of arc of vibration from zero at 40th vibration.
Observations previous to heating the compass-box.		63.0	139.65 seconds.	15° 00′
			139.2	13 00
			139.25	13 00
		64.0	139.4	13 00
Observations after the compass-box had been heated.	1st time	64.5	141.3	21 00
			139.6	12 45
			139.3	12 30
		64.7	139.5	12 30
	2d time	64.0	141.6	20 00
			140.0	15 00
			140.2	15 00
		63.5	140.0	15 30
	3d time	63.4	141.4	20 00
			140.2	14 30
			139.6	12 45
		63.0	139.7	12 00

These observations show clearly that an increased temperature on the compass-box tended to increase considerably the terminal arc, and that if the increased temperature, and consequent diminished intensity of the needle, had any tendency to diminish that arc, it was much more than counterbalanced by the effect produced on the compass-box. That such an effect should be produced on the brass is singular, and can, I think, only be accounted for on the supposition, that the capacity in brass for the developement of magnetism by induction is diminished by an increase of temperature, the vibrations of the needle being in all cases checked by the magnetism developed in the brass by the needle itself.*

* Since making the foregoing observations I have found that a similar effect, arising, I conceive, from the same cause, is produced on a copper disc vibrating under the influence of a magnet: the number of vibrations required to reduce the

I now proposed observing the effect on the terminal arc of a change of temperature, and consequently a change of intensity in the needle, other circumstances remaining precisely the same. For this purpose, I plunged the ends of the needle nearly to its centre into boiling water, and vibrated it as soon as possible afterwards. On my first doing this the pivot on which the needle vibrated was slightly injured, so that being obliged to re-magnetise the needle, in order to obtain results previous to a diminution of intensity to be compared with those after the needle had been immersed, these results could not be compared with those which I had before obtained. I mention this, to guard against any conclusions being drawn from a comparison of the times of vibration or of the terminal arcs in the following observations with those of the preceding. In consequence of the increased friction on the pivot, the arc of vibration was reduced to $5\frac{1}{2}°$ on each side of zero at the 30th vibration, I therefore only observed that number: the vibrations commenced, as before, 90° from zero.

arc of vibration to a certain extent was, by heating the disc, increased from being less than 23 to $26\frac{1}{2}$, taking a mean of several observations. The method of vibrating metallic discs between the poles of a magnet, which I here made use of, was, I believe, first employed by Mr. William Sturgeon, of Woolwich, for the purpose of exhibiting the magnetic properties of different metals, which it does in a very striking manner.

	Thermometer.	Time of performing 30 vibrations.	Extent of arc of vibration from zero at 30th vibration.
The needle having been re-magnetised previous to immersion in boiling water.	63°	99.9 seconds.	5° 15′
		99.8	5 30
		99.7	5 30
		99.7	5 30
	Mean	99.775	5 26
The needle having been immersed in boiling water.	63	104.2	6 00
		104.15	6 15
		104.25	6 15
		104.4	6 15
	Mean	104.25	6 11
The needle having been re-magnetised after immersion in boiling water.	63	100.2	6 15
		100.4	6 30
		100.3	6 30
		100.4	6 45
	Mean	100.325	6 30

The increase here in the terminal arcs being gradual, and taking place under opposite circumstances, appears to have arisen from the friction on the pivot being gradually diminished. Taking a mean of the arcs before immersion and after it, when the needle had been re-magnetised, it is rather less than the mean arc when the intensity of the needle was reduced by an increased temperature arising from the immersion; so that an increase of temperature which diminished the intensity of the needle from 1 to 0.92, produced no sensible effect on the terminal arc. The decrease of intensity is here much greater than any that could arise from an increase of temperature derived from the direct rays of the sun; it is therefore manifest from these last experim ents, independent of any thing which I have before stated, that the heat of the sun, by diminishing the intensity, could not be the cause of

the diminution of the terminal arc. That this diminution could not arise from the increased temperature of the compass-box, the previous experiments have, I trust, satisfactorily proved: I think I may therefore safely conclude, that during the vibration of a magnetised needle exposed to the solar rays, these rays have an influence on the needle independent of the effect produced by heat, which tends to bring the needle to a state of rest.

In the first observations which I have described it appears that, although we might expect that, when the needle vibrated in the sun, the increased temperature would diminish the intensity, yet a slight acceleration took place in the time of vibration. Whether this is to be attributed to the same cause or not, it is perfectly analogous to what I have observed on vibrating a metallic disc under the influence of a magnet: the arc of vibration was much more rapidly diminished than when the disc vibrated uninfluenced by the magnet, and the times of vibration were also diminished. A copper disc 7 inches in diameter having its axis of suspension perpendicular to its plane, and at a small distance from its centre, made 286 vibrations before the arc of vibration was reduced to a certain extent; but on vibrating it between the poles of a horse-shoe magnet it made only 23 vibrations before the arc was reduced to the same extent. The times in which the disc performed 24 vibrations at different trials were:

	Freely.	Between the poles of the magnet.
24 vibrations in	35.15 seconds	34.6 seconds.
24	35.15	34.7
24	35.1	34.6
24	35.18	34.6
Time of 1 vibration	1.4635	1.4427

so that another effect of the magnet was to diminish the time of vibration of the disc. If the acceleration in the time of vibration of the needle when exposed to the sun's rays arise from a similar cause, we ought also to find that the decrement of intensity in the needle corresponding to an increase of temperature, as deduced from the times of vibration in the sun and in the shade, is less than the decrement deduced from the times of vibration at different temperatures when both observations were made in the shade, or both in the sun, and likewise less than that deduced from the deviation due to torsion; and this, from the observations, appears to have been decidedly the case. Probably, however, the accelerations in the times of vibration are only consequences of the diminution of the arcs, both in the case of the copper disc and of the needle vibrating in the sun; still this acceleration will account for these differences in the decrements of intensity.

Although we should not at present be able to point out the manner in which the rays of the sun tend to bring the needle to rest, the discovery of a fact proving magnetic influence in the solar rays must, I think, ultimately lead to important conclusions respecting the phænomena of terrestrial magnetism. On this account it is desirable that the mode of observing should be varied, and that observations should be made in climates more favourable for the purpose than our own. I regret that, in consequence of my absence from home, I could not repeat the experiments during the extremely hot and clear weather of the past summer, as it is probable that the effects might have been even more decided than those which I have detailed. Possibly the effect might

be greatly increased by placing the needle so nearly in the focus of a large lens or reflector, that the rays should be concentrated on the space in which the needle vibrated. In this case, however, the intensity of the needle might be so much diminished by the high temperature, as to render doubtful the cause of the effect observed.

The repeated failures of MORICHINI's experiment of magnetising a needle by the violet ray, even under the most favourable circumstances, and in the ablest hands, have led many to doubt whether the effects, which were in some cases observed, were to be attributed to the influence of the ray; but as the experiments which I have detailed indicate magnetic influence in the compound solar rays, and are besides easily repeated, they will, I think, tend considerably to remove these doubts.

Royal Military Academy,
November 15, 1825.

Additional observations.

Since the foregoing paper was read, having made some further observations which show more decidedly than the preceding that the effect which I have described is due to magnetic influcnce in the solar rays, I beg here to add them. I was satisfied that the decrease in the terminal arc, when the needle vibrated in the sun, could not be due to the increased temperature of the metallic compass-box in which the needle vibrated, since in the experiment which I have described, and which I have carefully repeated, the effect

produced by heating the box was to increase considerably that arc; yet I considered that it must remove all doubt on the subject, if the box in which the needle vibrated were of wood, or other non-metallic substance. I resolved therefore at the earliest opportunity to repeat my experiments, and to make additional ones with an apparatus, in the construction of which I had scrupulously excluded metal, the suspension of the needle alone excepted. The compass-box is of mahogany, the sides being of thick pasteboard: the graduations are on paper. Through a perforation in the middle of the glass cover a glass tube is fixed, and down this the suspending wire, which is fixed above, passes into the compass-box. The needle can be released 90° from zero by means of a wooden or glass pin, turning in the side of the box. It would have been very desirable to have repeated the experiments in a vacuum, as the effect which I had observed to be produced by vibrating the needle exposed to the sun, might possibly be attributed to changes taking place in the medium in which the needle moved; but as there would be extreme difficulty in doing this without having metal in the vicinity of the needle, I proposed to vibrate needles of copper and of glass, by the force of torsion, both in the shade and exposed to the sun, to observe the terminal arcs under those circumstances, and to compare the effects with those obtained with a magnetised needle. The needles employed are all of the same form; their length 6 inches, breadth in the middle 1.5 inches, their sides being nearly circular arcs. The magnetised needle was suspended by a very fine hard brass wire, No. 35, between $\frac{1}{300}$ and $\frac{1}{400}$ inch in diameter, and 10 inches in length; the glass needle was suspended by the same

length of No. 18; and the copper needle by the same length of this wire doubled. In vibrating these needles they were released 90° from zero; and in order to be certain that the extent of the first vibration was the same when the needle vibrated in the sun as when it vibrated in the shade, I noted also the extent of the arc of vibration on the other side of zero. The observations were made in the open air at a distance from my house: the compass-box was placed on a wooden tripod about 2 feet from the ground, and 5 feet from the north side of a garden wall, on which a wooden screen, moveable at pleasure, rested $3\frac{1}{2}$ feet above the box. The following are the results which I obtained.

Nature and Weight of the needle vibrated.	No. of vibrations performed.	Needle vibrated in the sun.				Needle vibrated in the shade.				Terminal excess.
		Extent of first vibration.	Time.	Terminal arc.	Therm.	Extent of first vibration.	Time.	Terminal arc.	Therm.	
		° °	m. sec.	°	°	° °	m. sec.	°	°	°
Magnetised steel,	100	90 + 90	5 55.4	20	100	90 + $89\frac{3}{4}$	5 58.6	33	47	13
	100	90 + $89\frac{3}{4}$	5 55.2	$19\frac{3}{4}$	104	90 + 90	5 58.8	$33\frac{3}{4}$	48	14
	100	90 + $89\frac{3}{4}$	5 55.1	$19\frac{1}{2}$	106	90 + $89\frac{3}{4}$	5 58.8	$33\frac{3}{4}$	$46\frac{1}{2}$	$14\frac{1}{4}$
Weight = grains. $225\frac{1}{2}$	Means	90 + $89\frac{5}{6}$	5 55.23	$19\frac{3}{4}$	103.3	90 + $89\frac{5}{6}$	5 58.7	$33\frac{1}{2}$	50.5	$13\frac{3}{4}$
	1st April, from $9^h\ 47^m$ to $10^h\ 15^m$.					1st April, from $10^h\ 19^m$ to $10^h\ 45^m$.				
Glass,	100	90 + 88	6 27.2	17	96	90 + 88	6 27.0	23	49	6
	100	90 + 88	6 27.1	18	99	90 + 88	6 27.2	23	47	5
	100	90 + 88	6 27.2	$17\frac{3}{4}$	100	90 + $87\frac{3}{4}$	6 27.1	22	47	$4\frac{1}{4}$
Weight = grains. $224\frac{1}{2}$	Means	90 + 88	6 27.17	$17\frac{7}{12}$	98.3	90 + 88	6 27.1	$22\frac{2}{3}$	47.7	$5\frac{1}{12}$
	1st April, from $10^h\ 58^m$ to $11^h\ 27^m$.					1st April, from $11^h\ 53^m$ to $0^h\ 20^m$:				
Copper,	100	90 + 93	7 40.2	24	93	90 + $93\frac{1}{2}$	7 39.6	$30\frac{1}{4}$	51	$6\frac{1}{4}$
	100	90 + 94	7 40.2	24	98	90 + 94	7 39.4	31	$49\frac{1}{2}$	7
	100	90 + $93\frac{1}{2}$	7 40.0	24	103	90 + $93\frac{3}{4}$	7 39.5	31	$49\frac{1}{2}$	7
Weight = grains. 543	Means	90 + $93\frac{1}{2}$	7 40.13	24	98	90 + $93\frac{3}{4}$	7 39.5	$30\frac{3}{4}$	50	$6\frac{3}{4}$
	1st April, from $1^h\ 20^m$ to $1^h\ 53^m$.					1st April, from $2^h\ 5^m$ to $2^h\ 35^m$.				

In whatever way we may attempt to account for the terminal arc of vibration, when a needle is screened from the sun, exceeding that when it vibrates exposed to the rays, (which excess I have called the terminal excess) the result here obtained with the glass needle is certainly extraordinary: as compared with that obtained with the magnetised needle, it shows decidedly that the solar rays exert a peculiar influence on a magnetised needle during its vibration: considered separately, either that glass is magnetic, which is scarcely probable, since its magnetism is not detected by rotating a magnet under it, or that the rays produce an effect distinct and independent of their magnetical effect.

These observations were made consecutively without even moving the compass-box; but it is scarcely possible, especially at the present season of the year, to make such a series under precisely the same circumstances of temperature of the air and of solar heat, by which alone we can in this case judge of the intensity of the action of the sun. The change which took place during the observations was probably not quite so great as I have registered, since in the first observation with the magnetised needle the glass had been closed over the thermometer for some time before I registered its height; and in the first observations with the other needles it had been open and in the shade, for the preceding observations, until very nearly that time; so that 100,99 and 98 would probably indicate more correctly the comparative elevations of the thermometer in the first observations with the different needles than 100,96 and 93, which I have registered. But even taking the latter, the small difference 5° would produce little difference in the results, and is much

more than counterbalanced by the time during which the glass and copper needles vibrated being greater than that for the magnetised needle. If the effects be reduced proportionally to the times, the terminal excess in the same time would be for the magnetised needle $13°.75$, for the copper needle $5°.24$, and for the glass needle $4°.71$.

The diminution in the time of vibration of the magnetised needle when exposed to the sun, may at first sight appear singular, since there can be no doubt that, the temperature being higher, the intensity of the needle was less than when it was screened. This diminution in the time of vibration I have no doubt arose principally from the more rapid diminution of the arcs of vibration in the former case than in the latter, and likewise in some measure from the needle not recovering the same intensity of magnetism after being exposed to the high temperature of the sun's rays which it previously possessed. That these causes operated to a great extent is clearly shown by the following observations which I afterwards made. The same needle, but having its weight increased to 252 grains, was first vibrated in the shade from 90° as before, and three different observations gave me $5^m\ 58^s.8$, $5^m\ 58^s.6$, $5^m\ 58^s.6$, as the time of performing 100 vibrations, or $3^s.587$ as the mean time of 1 vibration, the terminal arc being 33 and thermometer 64.5. I then vibrated it, still in the shade, from 20°, and found that 50 vibrations were performed in $2^m\ 48^s.8$, giving $3^s.376$ as the mean time of vibration, the terminal arc being 13° and thermometer 65°. Similar observations being immediately afterwards made with the needle exposed to the sun, gave $5^m\ 59^s.4$, $5^m\ 59^s.4$, and $6^m\ 00^s$, as the time of performing 100 vibrations, or

$3^s.596$ as the mean time of one vibration, when the needle vibrated from 90°, the terminal arc being $19\frac{1}{3}°$ and thermometer 102.3; and vibrated from 20°, the time of performing 50 vibrations was 2 52.2, or the mean time of one vibration 3.445, the terminal arc being 9° and thermometer 110. The intensities in the shade and in the sun, estimated by the times of vibration in the large arcs would be 1 and .995; but estimated by the times of vibration in the small arcs 1 and .960. It appears from these observations, that in deducing the magnetic intensity in different parts of the earth from the vibrations of a needle, it is very essential to attend to the circumstance of the needle having been exposed or not to the rays of the sun during its vibration, as well as to the temperature in which the vibrations have been made.

The very small increase in the times of vibration of the glass and copper needles, when exposed to the sun above those when screened, is to be attributed to the slight expansion of the needles themselves, and perhaps of the suspending wires; but this is too small at all to account for the terminal excess with these needles. I am aware that, had the copper needle been of the same weight as the magnetised needle, and the times of vibration of all the needles more nearly the same, in the series of experiments which I have given, the results would have been more strictly comparative; but on the only day during which to the present time the sun has continued unclouded long enough for making a complete series with different needles, I was unprovided with any lighter copper; and since I have formed needles of magnetised and unmagnetised sheets of copper and of glass, all of the same form and weight, and adjusted the suspending

wire so that they shall vibrate in the same time, I have in vain made almost daily attempts to obtain a complete set of observations. The observations however which I have given are, I think, quite conclusive as to the fact of the compound solar rays being possessed of magnetic properties.

As we can scarcely suppose that the terminal excess in the case of the glass needle is due to magnetism in the glass, deducting this portion from the terminal excess with the other needles, the ratio of this excess with the magnetised needle to that with the copper needle would be 17 to 1, a result not very improbable, though the small difference in this excess with the copper and glass needles may very possibly have arisen from other causes. But if the effect with the glass needle cannot be attributed to magnetic influence any how exerted, what cause are we to assign for it? It is possible that the terminal excess in this case may have arisen from currents of air excited within the box by the rays of the sun: or probably electricity is excited in the glass needle on exposure to the rays of the sun, and the box becoming electric by induction, a drag between the needle and the box causes a diminution in the arc of vibration. The latter supposition would accord with the recent highly interesting experiments of Mr. BABBAGE. I am not aware that such effects as these have ever before been observed during vibration, and there certainly appears great difficulty in assigning any cause for them: however, until further observations may have thrown greater light on the subject, we must be satisfied with having ascertained the facts.

I have not as yet made any observations to ascertain what may be the effects when a needle vibrates exposed to the

separated rays, but having an apparatus for the purpose, I propose doing so when the season becomes more favourable for such experiments than it is at present.

Royal Military Academy,
20th April, 1826.